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CLAIMS

What is claimed is:

1. A process for determining polymer properties in a polymerization reactor system, the process comprising:

   (a) obtaining a regression model for determining a polymer property, the regression model including principal component loadings and principal component scores;

   (b) acquiring a Raman spectrum of a sample comprising polyolefin;

   (c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings; and

   (d) calculating the polymer property by applying the new principal component score to the regression model;

   wherein the Raman spectrum acquired in step (b) is acquired from a Raman probe inserted *in situ* into the polymerization reactor system.

2. The process of claim 1, wherein the step of obtaining a regression model comprises:

   (i) obtaining a plurality of Raman spectra of samples comprising polyolefins;

   (ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and

   (iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polymer property to the principal component scores.

3. The process of claim 1, wherein the regression model is a locally weighted regression model.

4. The process of claim 1, wherein the polymer property is selected from density, melt flow rate, molecular weight, molecular weight distribution, and functions thereof.

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5. The process of claim 1, wherein the sample comprises polyolefin particles.

6. The process of claim 1, wherein the step of acquiring a Raman spectrum comprises: (i) irradiating the sample of polyolefin and collecting scattered radiation during a sampling interval using a sampling probe, and (ii) purging polymer from said Raman probe during a purging interval.

7. The process of claim 1, wherein the polymerization reactor is a fluidized-bed reactor.

8. The process of claim 1, further comprising:
   (i) obtaining a second regression model for determining a second polymer property, the second regression model including second principal component loadings and second principal component scores;
   (ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and
   (iii) calculating the second polymer property by applying the new second principal component score to the second regression model.

9. The process of claim 1, wherein the Raman probe is inserted *in situ* into said polymerization reactor system in a location where granular polymer is moving.

10. The process of claim 1, wherein the Raman probe is inserted *in situ* into at least one of the locations within said polymerization reactor system selected from the group consisting of the cycle gas piping, the product discharge system downstream of the exiting point of product, the transfer line between the product discharge system and the purger(s)/degasser(s),

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one or more of the purger(s)/degasser(s), the transfer line to finishing/pack-out, and the feed bins to the extruder/mixer.

11. The process of claim 1, wherein the Raman probe is inserted *in situ* into the reactor body.

12. The process of claim 1, further comprising purging polymer from said Raman probe.

13. A process for determining polymer properties in a fluidized-bed reactor system, the process comprising:

(a) obtaining a locally weighted regression model for determining a polymer property selected from density, melt flow rate, molecular weight, molecular weight distribution, and functions thereof, the locally weighted regression model including principal component loadings and principal component scores;

(b) acquiring a Raman spectrum of a sample comprising polyolefin particles;

(c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings; and

(d) calculating the polymer property by applying the new principal component score to the locally weighted regression model

wherein the Raman spectrum acquired in step (b) is acquired from a Raman probe inserted *in situ* into the polymerization reactor system.

14. The process of claim 13, wherein the step of obtaining a regression model comprises:

(i) obtaining a plurality of Raman spectra of samples comprising polyolefins;

(ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and

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(iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polymer property to the principal component scores.

15. The process of claim 13, wherein the step of acquiring a Raman spectrum comprises:

(i) providing the sample of polyolefin particles; and

(ii) irradiating the sample and collecting scattered radiation during a sampling interval using a sampling probe,

wherein there is relative motion between the sample and the sampling probe during at least a portion of the sampling interval.

16. The process of claim 13, further comprising:

(i) obtaining a second regression model for determining a second polymer property, the second regression model including second principal component loadings and second principal component scores;

(ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and

(iii) calculating the second polymer property by applying the new second principal component score to the second regression model.

17. The process of claim 13, wherein the Raman probe is inserted *in situ* into said polymerization reactor system in a location where granular polymer is moving.

18. The process of claim 13, wherein the Raman probe is inserted *in situ* into at least one of the locations within said polymerization reactor system selected from the group consisting of the cycle gas piping, the product discharge system downstream of the exiting point of product, the transfer line between the product discharge system and the purger(s)/degasser(s),

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one or more of the purger(s)/degasser(s), the transfer line to finishing/pack-out, and the feed bins to the extruder/mixer.

19. The process of claim 13, wherein the Raman probe is inserted *in situ* into the reactor body.

20. The process of claim 13, further comprising a step of purging polymer from said Raman probe.

21. A process for controlling polymer properties in a polymerization reactor system, the process comprising:

(a) obtaining a regression model for determining a polymer property, the regression model including principal component loadings and principal component scores;

(b) acquiring a Raman spectrum of a sample comprising polyolefin;

(c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings;

(d) calculating the polymer property by applying the new principal component score to the regression model; and

(e) adjusting at least one polymerization parameter based on the calculated polymer property;

wherein the Raman spectrum acquired in step (b) is acquired from a Raman probe inserted *in situ* into the polymerization reactor system.

22. The process of claim 21, wherein the step of obtaining a regression model comprises:

(i) obtaining a plurality of Raman spectra of samples comprising polyolefins;

(ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and

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(iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polymer property to the principal component scores.

23. The process of claim 21, wherein the regression model is a locally weighted regression model.

24. The process of claim 21, wherein the polymer property is selected from density, melt flow rate, molecular weight, molecular weight distribution, and functions thereof.

25. The process of claim 21, wherein the sample comprises polyolefin particles.

26. The process of claim 21, wherein the step of acquiring a Raman spectrum comprises: (i) irradiating the sample of polyolefin and collecting scattered radiation during a sampling interval using a sampling probe, and (ii) purging polymer from said Raman probe during a purging interval.

27. The process of claim 21, wherein the polymerization reactor is a fluidized-bed reactor.

28. The process of claim 21, wherein the at least one polymerization parameter is selected from the group consisting of monomer feed rate, comonomer feed rate, catalyst feed rate, hydrogen gas feed rate, and reaction temperature.

29. The process of claim 21, further comprising:

(i) obtaining a second regression model for determining a second polymer property, the second regression model including second principal component loadings and second principal component scores;

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(ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and

(iii) calculating the second polymer property by applying the new second principal component score to the second regression model,

and wherein the step of adjusting comprises adjusting at least one polymerization parameter based on the calculated polymer property, the calculated second polymer property, or both calculated polymer properties.

30. A process for controlling polymer properties in a fluidized reactor system, the process comprising:

(a) obtaining a locally weighted regression model for determining a polymer property selected from density, melt flow rate, molecular weight, molecular weight distribution, and functions thereof, the locally weighted regression model including principal component loadings and principal component scores;

(b) acquiring a Raman spectrum of a sample comprising polyolefin particles;

(c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings;

(d) calculating the polymer property by applying the new principal component score to the locally weighted regression model; and

(e) adjusting at least one polymerization parameter based on the calculated polymer property;

wherein the Raman spectrum acquired in step (b) is acquired from a Raman probe inserted *in situ* into the polymerization reactor system.

31. The process of claim 30, wherein the step of obtaining a regression model comprises:

(i) obtaining a plurality of Raman spectra of samples comprising polyolefins;

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(ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and

(iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polymer property to the principal component scores.

32. The process of claim 30, wherein the step of acquiring a Raman spectrum comprises:

(i) providing the sample of polyolefin particles; and

(ii) irradiating the sample and collecting scattered radiation during a sampling interval using a sampling probe,

wherein there is relative motion between the sample and the sampling probe during at least a portion of the sampling interval.

33. The process of claim 30, wherein the at least one polymerization parameter is selected from the group consisting of monomer feed rate, comonomer feed rate, catalyst feed rate, hydrogen gas feed rate, and reaction temperature.

34 The process of claim 30, further comprising:

(i) obtaining a second regression model for determining a second polymer property, the second regression model including second principal component loadings and second principal component scores;

(ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and

(iii) calculating the second polymer property by applying the new second principal component score to the second regression model,

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and wherein the step of adjusting comprises adjusting at least one polymerization parameter based on the calculated polymer property, the calculated second polymer property, or both calculated polymer properties.

35. In a gas phase polymerization reactor system wherein gaseous monomer is introduced into a reactor body and polymer is discharged from the reactor, the improvement comprising inserting a Raman probe *in situ* into said reactor system, whereby a Raman spectrum correlated to at least one property selected from the group consisting of a polymer property and a reactor operability property is obtained.

36. The gas phase polymerization reactor system according to Claim 35, wherein the Raman probe is inserted *in situ* into at least one of the locations within said polymerization reactor system selected from the group consisting of the cycle gas piping, the product discharge system downstream of the exiting point of product, the transfer line between the product discharge system and the purger(s)/degasser(s), one or more of the purger(s)/degasser(s), the transfer line to finishing/pack-out, and the feed bins to the extruder/mixer.

37. In a gas phase polymerization process including a polymerization reactor system wherein gaseous monomer is introduced into a reactor body, polymer is produced in said reactor body, and polymer product is discharged from the reactor, the improvement comprising acquiring a Raman spectrum correlated with at least one property selected from the group consisting of a polymer property and a reactor operability property.

38. The process according to claim 37, wherein said Raman spectrum is acquired by a Raman probe inserted *in situ* into said polymerization reactor system.

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39. The process according to claim 38, wherein the Raman probe is inserted *in situ* into at least one of the locations within said polymerization reactor system selected from the group consisting of the cycle gas piping, the product discharge system downstream of the exiting point of product, the transfer line between the product discharge system and the purger(s)/degasser(s), one or more of the purger(s)/degasser(s), the transfer line to finishing/pack-out, and the feed bins to the extruder/mixer..

40. The process according to claim 38, further comprising purging polymer from said Raman probe.

41. The process according to claim 38, wherein said purging comprises purging with a stream of nitrogen gas or monomer.

42. The process according to claim 38, further comprising:

(a) obtaining a regression model for determining a polymer property or a property correlated with reactor operability, the regression model including principal component loadings and principal component scores;

(b) acquiring a Raman spectrum of a sample comprising polyolefin;

(c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings; and

(d) calculating the polymer property or property correlated with reactor operability by applying the new principal component score to the regression model.

43. The process according to claim 42, further comprising adjusting at least one polymerization parameter based on the polymer property or property correlated with reactor operability.

44. The process according to claim 43, wherein the at least one polymerization parameter is selected from at least one of the group consisting of monomer

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feed rate, comonomer feed rate, catalyst feed rate, hydrogen gas feed rate, and reaction temperature.

45. The process according to claim 37, wherein said Raman spectrum is acquired by extractive sampling from said polymerization reactor system.

46. The process according to claim 45, wherein said extractive sampling is from at least one of the locations within said polymerization reactor system selected from the group consisting of the cycle gas piping, the product discharge system downstream of the exiting point of product, the transfer line between the product discharge system and the purger(s)/degasser(s), one or more of the purger(s)/degasser(s), the transfer line to finishing/pack-out, and the feed bins to the extruder/mixer.

47. In a gas phase polymerization reactor system wherein gaseous monomer is introduced into a reactor body and polymer is discharged from the reactor, the improvement comprising providing a Raman probe in an extractive sampling system whereby a Raman spectrum correlated to at least one property selected from the group consisting of a polymer property and a reactor operability property is obtained.

48. The gas phase polymerization reactor system according to Claim 47, wherein the extractive sampling system extracts polymer from a location selected from the group consisting of the cycle gas piping, the product discharge system downstream of the exiting point of product, the transfer line between the product discharge system and the purger(s)/degasser(s), one or more of the purger(s)/degasser(s), the transfer line to finishing/pack-out, and the feed bins to the extruder/mixer.